

In the Claims:

Please amend Claims 1-4, 6-8, 11-14, 16-18, 22, 24 and 25 and add Claim 29 as follows. A marked-up copy of Claims 1-4, 6-8, 11-14, 16-18, 22, 24 and 25 showing the changes made thereto, is attached. Note that all the claims currently pending in this application, including those not presently amended, have been reproduced below for the Examiner's convenience.

1. (Four Times Amended) An illumination optical system having a total reflection type light transmitting element, for illuminating a surface to be illuminated, said illumination optical system comprising:

an imaging optical system for forming an image of a light source by use of light from the light source; and

a converting optical system for directing light from the light source image formed by said imaging optical system, to the light transmitting element, said converting optical system having a numerical aperture, at the light transmitting element side which is not greater than a numerical aperture of the light transmitting element.

2. (Amended) An illumination optical system having a total reflection type light transmitting element, for illuminating a surface to be illuminated, said illumination optical system comprising:

an imaging optical system for forming an image of a light source upon a predetermined plane by use of light from the light source, wherein a luminous intensity

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distribution upon the predetermined plane has a distribution of a shape with a central void;
and

a converting optical system for directing light from the light source image formed by said imaging optical system, to said light transmitting element, said converting optical system being effective to make a luminous intensity distribution upon a light entrance surface of said light transmitting element into a distribution of a shape without a central void;

wherein a diameter of flux of light upon the predetermined plane is substantially equal to a diameter of flux of light upon the light entrance surface of the light transmitting element.

3. (Amended) An illumination optical system according to Claim 2, wherein the light source image formed by said imaging optical system has an illuminance which is larger in a portion adjacent an optical axis of the light transmitting element than in a peripheral portion about the optical axis.

4. (Amended) An illumination optical system according to Claim 2, wherein said imaging optical system includes an elliptical mirror, wherein the light source is disposed at one focal point of said elliptical mirror, and wherein the light source image formed by said imaging optical system is defined at another focal point of said elliptical mirror.

5. An illumination optical system according to Claim 2, wherein the light source comprises a Hg lamp.

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6. (Amended) An illumination optical system according to Claim 2, wherein said converting optical system includes first and second lens units having the same focal distance and being disposed so that a distance between principal points of the two lens units becomes equal to the focal distance, and wherein an entrance pupil of the first lens unit is disposed substantially in coincidence with the light source image formed by said imaging optical system, while an exit pupil of the second lens unit is disposed substantially in coincidence with a light entrance surface of said light transmitting element.

7. (Amended) An illumination optical system according to Claim 2, wherein said converting optical system includes an optical rod and a lens unit, wherein a light entrance surface of the optical rod is disposed substantially in coincidence with the light source image formed by said imaging optical system, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the optical rod, while another focal point position of the lens unit is disposed substantially in coincidence with a light entrance surface of said light transmitting element.

8. (Amended) An illumination optical system according to Claim 2, wherein said imaging optical system includes fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the light

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source image formed by said imaging optical system, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with a light entrance surface of said light transmitting element.

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11. (Amended) An illumination optical system for illuminating a surface to be illuminated, with light from a light source and by use of an optical fiber bundle, said illumination optical system, comprising:

an imaging optical system for forming an image of a light source by use of light from the light source; and

a converting optical system for directing light from the light source image formed by said imaging optical system, to the optical fiber bundle, said converting optical system having a numerical aperture at the optical fiber bundle side which is not greater than a numerical aperture of the optical fiber bundle.

12. (Amended) An illumination optical system, for illuminating a surface to be illuminated, with light from a light source and by use of an optical fiber bundle, said illumination optical system comprising:

an imaging optical system for forming an image of a light source on a predetermined plane, by use of light from the light source, wherein a luminous intensity distribution upon the predetermined plane has a distribution of a shape with a central void; and

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a converting optical system for directing light from the light source image formed by said imaging optical system, to said optical fiber bundle, said converting optical system being effective to make a luminous intensity distribution upon a light entrance surface of said optical fiber bundle into a distribution of a shape without a central void;

wherein a diameter of flux of light upon the predetermined plane is substantially equal to a diameter of flux of light upon the light entrance surface of said optical fiber bundle.

13. (Twice Amended) An illumination optical system according to Claim 12, wherein the light source image formed by said imaging optical system has an illuminance which is larger in a portion adjacent an optical axis of the light transmitting element than in a peripheral portion about the optical axis.

14. (Amended) An illumination optical system according to Claim 12, wherein said imaging optical system includes an elliptical mirror, wherein the light source is disposed at one focal point of said elliptical mirror, and wherein the light source image formed by said imaging optical system is defined at another focal point of said elliptical mirror.

15. An illumination optical system according to Claim 12, wherein the light source comprises a Hg lamp.

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16. (Twice Amended) An illumination optical system according to Claim 12, wherein said converting optical system includes first and second lens units having the same focal distance and being disposed so that a distance between principal points of the two lens units becomes equal to the focal distance, and wherein an entrance pupil of the first lens unit is disposed substantially in coincidence with the light source image formed by said imaging optical system, while an exit pupil of the second lens unit is disposed substantially in coincidence with a light entrance surface of said optical fiber bundle.

17. An illumination optical system according to Claim 12, wherein said converting optical system includes an optical rod and a lens unit, wherein a light entrance surface of the optical rod is disposed substantially in coincidence with the light source image formed by said imaging optical system, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the optical rod, while another focal point position of the lens unit is disposed substantially in coincidence with a light entrance surface of said optical fiber bundle.

18. (Amended) An illumination optical system according to Claim 12, wherein said converting optical system includes a fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the light source image formed by said imaging optical system, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of

16

the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with a light entrance surface of said optical fiber bundle.

19. An illumination optical system according to Claim 12, wherein said optical fiber bundle has a light entrance of one of square shape and rectangular shape, and a light exit face of arcuate shape.

20. An illumination optical system according to Claim 12, wherein said optical fiber bundle comprises a total reflection type fiber bundle.

21. An illumination optical system according to Claim 12, wherein said optical fiber bundle comprises a distributed refractivity type optical fiber bundle.

22. (Amended) An illumination optical system having a total reflection type light transmitting element, for illuminating a surface to be illuminated, said illumination optical system comprising:

a light source for illuminating a predetermined plane, wherein a luminous intensity distribution upon the predetermined plane has a distribution of a shape with a central void; and

a converting optical system disposed between the predetermined plane and said light transmitting element, for directing light from the light source to said light transmitting element, said converting optical system being effective to make a

27
luminous intensity distribution upon a light entrance surface of said light transmitting element into a distribution of a shape without a central void,

wherein a diameter of flux of light upon the predetermined plane is substantially equal to a diameter of flux of light upon the entrance surface of said light transmitting element.

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23. An illumination optical system according to Claim 22, wherein said light transmitting element comprises an optical rod.

28
24. (Amended) An illumination optical system according to Claim 22, wherein the light source comprises a plurality of laser light sources.

25. (Amended) An exposure apparatus, comprising:
an illumination optical system as recited in any one of Claims 1, 2, 11, 12, 22 and 27; and
a projection optical system for transferring, by exposure, a pattern of a mask as illuminated with said illumination [optical] system, onto a wafer.

26. A device manufacturing method, comprising steps of:
applying a resist to a wafer;
transferring, by exposure, a pattern of a mask onto the wafer by use of an exposure apparatus as recited in Claim 25; and

developing the wafer having the pattern transferred thereto.

Please add new Claim 29 as follows:

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--29. (New) An illumination optical system, for illuminating a surface to be illuminated, by use of an optical fiber bundle, said illumination optical system comprising:

a light source for illuminating a predetermined plane, wherein a luminous intensity distribution upon the predetermined plane has a distribution of a shape with a central void; and

a converting optical system disposed between the predetermined plane and said optical fiber bundle, for directing light from the light source to said optical fiber bundle, said converting optical system being effective to make a luminous intensity distribution upon a light entrance surface of said optical fiber bundle, into a distribution without a central void,

wherein a diameter of flux of light upon the predetermined plane is substantially equal to a diameter of flux of light upon the light entrance surface of said optical fiber bundle.--

REMARKS

Claims 9, 10, 27 and 28 having been withdrawn from consideration, Claims 1-8, 11-26 and 29 are now presented for examination. Claims 1-4, 6-8, 11-14, 16-18, 22,

24 and 25 have been amended to define still more clearly what Applicant regards as his invention, in terms which distinguish over the art of record. Claim 29 has been added to assure Applicant of the full measure of protection to which he deems himself entitled.

Claims 1, 2, 11, 12, 22 and 29 are the only independent claims.

The specification has been objected to for informalities at line 23 of page 11, lines 10 and 15 at page 17 and line 3 of page 19. A substitute specification has been filed on May 14, 2002 which corrects these informalities.

The specification has been further objected to as not including the terms "a light directing optical system" and "a light collecting optical system". The objected-to terms "a light directing optical system" in Claims 1, 2, 12 and 22 and "a light collecting optical system" have been changed to "converting optical system" which is shown in the drawings and disclosed in the specification.

Claims 1-8 and 11-26 have been rejected under 35 U.S.C. § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the art that the inventor at the time the application was filed has possession of the claimed invention.

Claim 1 as amended by this amendment now recites "said converting optical system having a numerical aperture, at the light transmitting element side which is not greater than a numerical aperture of the light transmitting element". Claim 11 has been similarly amended. This feature of Claim 1 and the similar feature of Claim 11 are believed to be fully supported by the disclosure in the specification as originally filed at

lines 16-21 of page ~~13~~¹¹ with respect to Fig. 9 and at lines 7-15 of page ~~15~~¹³ with respect to Fig. 11.

Claim 2 as amended now recites "said converting optical system being effective to make a luminous intensity distribution upon a light entrance surface of said light transmitting element into a distribution of a shape without a central void, wherein a diameter of flux of light upon the predetermined plane is substantially equal to a diameter of flux of light upon the light entrance surface of the light transmitting element". Claims 12 and 22 have been similarly amended. This feature of Claims 2, 12 and 22 is believed to be fully supported by the disclosure in the specification as originally filed at lines 1-23 of page 5 with respect to Fig. 6, lines 2-4 and 16-21 of page 13 with respect to Fig. 3, lines 7-15 of page 15 with respect to Fig. 11 and the luminous intensity distribution shown in Fig. 14.

In view of the foregoing, it is believed that the subject application fully meets the requirements of 35 U.S.C. § 112, first paragraph..

Claims 1-8 and 11-26 have been rejected under 35 U.S.C. § 112, second paragraph as being indefinite. The claims have been amended taking into account the objections noted by the Examiner to provide definite recitations of the objected-to terms. It is believed that Claims 1-8 and 11-26 as amended by this amendment fully meet the requirements of 35 U.S.C. § 112, second paragraph.

Claims 1-4 and 11-14 have been rejected under 35 U.S.C. § 102(e) as anticipated by U.S. Patent 5,971,576 (Tomioka et al.). Claims 5 and 15 have been rejected

under 35 U.S.C. § 103(a) as unpatentable over Tomioka et al. With regard to the claims as amended by this amendment, these rejections are respectfully traversed.

Independent Claim 1 as amended by this amendment is directed to an illumination optical system having a total reflection type light transmitting element that illuminates a surface. In the illumination optical system, an imaging optical system forms an image of a light source using light from the light source. A converting optical system directs light from the light source image formed by the image optical system to the light transmitting element. The converting optical system has a numerical aperture at the light transmitting side which is not greater than the numerical aperture of the light transmitting element.

Independent Claim 11 as amended is directed to an illumination optical system that illuminates a surface with light from a light source by use of an optical fiber bundle. In the illumination optical system, an imaging optical system forms an image of a light source using light from the light source. A converting optical system directs light from the light source image formed by the imaging optical system to the optical fiber bundle. The converting optical system has a numerical aperture at the optical fiber bundle side which is not greater than the numerical aperture of the optical fiber bundle.

In Applicant's view, Tomioka et al. discloses a light source device for endoscopes that includes a light source. A condenser lens unit collects light beams from the light source and a light guide receives the light beams collected through the condenser lens unit into its entrance end face to transmit them to its exit end face. A reflecting mirror is located on the opposite side of the condenser lens unit with respect to the light source.

The light source device is designed so that the position where the light beams emitted from the light source are collected directly through the condenser lens unit does not coincide with a position where the light beams emitted from the light source and reflected back to the light source by the reflecting mirror are collected through the condenser lens unit.

According to the invention defined in Claims 1 and 11 as amended by this amendment, the numerical aperture of the converting optical system at the transmitting element or optical bundle side is not greater than the numerical aperture of the light transmitting element or the optical bundle. Advantageously, the feature of this numerical aperture relationship substantially increases the utilization efficiency for the light from the light source.

Tomioka et al. may teach an illumination optical system with a total reflection type light transmitting element. As clearly disclosed at lines 38-45 of column 9 in Tomioka et al. and shown in Fig. 8 thereof,

"The numerical aperture of the light guide 17 used in the light source device of the first embodiment is 0.66, and both the lens 14a and the spherical mirror 12 are constructed so that the light beam can be made efficiently incident on the light guide 17 of this numerical aperture. Specifically, the value of the paraxial relation between the focal length f_1 and the outer diameter D_1 of the lens 14a, $\sin \{\tan^{-1} (2 f_1 / D_1)\}$, is about 0.74, which is nearly equal to the numerical aperture of the light guide 17."

Accordingly, Tomioka et al. only discloses a structure in which the numerical aperture of the light guide 17 is 0.66 but the numerical aperture of the lens system 14 at the light guide 17

side is 0.74 so that the numerical aperture of the converting optical system in Tomioka et al. at the light transmitting element side is greater than the numerical aperture of the light transmitting element. As a result, it is not seen that Tomioka et al. could possibly teach the feature of Claims 1 and 11 of a converting optical system having a numerical aperture, at the light transmitting element side which is not greater than a numerical aperture of the light transmitting element. It is therefore believed That Claims 1 and 11 as amended by this amendment are completely distinguished from Tomioka et al. and are allowable.

Independent Claim 2 as amended is directed to an illumination optical system having a total reflection type light transmission element that illuminates a surface. In the illumination optical system, an imaging optical system forms an image of a light source upon a predetermined pane using light from the light source. The luminous intensity distribution upon the predetermined plane has a distribution shape with a central void. A converting optical system directs light from the light source image formed by the image optical system to the light transmitting element. A converting optical system directs light from the light source image formed by the imaging optical system to the light transmitting element. The converting optical system is effective to make the luminous intensity distribution upon a light entrance surface of light transmitting element into a distribution shape without a central void. The diameter of flux of light upon the predetermined plane is substantially equal to the diameter of flux of light upon the light entrance surface of the light transmitting element.

Independent Claim 12 as amended is directed to An illumination optical system that illuminates a surface with light from a light source using an optical fiber

bundle. In the illumination optical system, an imaging optical system forms an image of a light source on a predetermined plane using light from the light source. The luminous intensity distribution upon the predetermined plane has a distribution shape with a central void. A converting optical system directs light from the light source formed by the imaging optical system to the optical fiber bundle. The converting optical system is effective to make the luminous intensity distribution upon a light entrance surface of the optical fiber bundle into a distribution shape without a central void. The diameter of flux of light upon the predetermined plane is substantially equal to the diameter of flux of light upon the light entrance of the optical fiber bundle.

It is a feature of Claims 2 and 12 that the converting optical system which directs light from the light source formed by the imaging optical system to the optical fiber bundle is effective to make the luminous intensity distribution upon a light entrance surface of light transmitting element (optical fiber bundle) into a distribution shape without a central void. Advantageously, the conversion to a distribution without a central void substantially increases the utilization efficiency for the light from the light source.

As discussed with respect to Claims 1 and 11, Tomioka et al. teaches an illumination optical system with a total reflection type light transmitting element. Fig. 16 of Tomioka et al., however, clearly shows that the light beam is blocked by an arc 25 so that the distribution that is produced has a central void (see lines 52-56 of column 13). The lens system of Tomioka et al. images a light source image directly on the light entrance surface of the light guide without specifically changing the luminous intensity distribution. As a result, the luminous intensity distribution upon the light entrance surface of the light

guide has a central void. Accordingly, it is not seen that Tomioka et al. could possibly teach or suggest the feature of a converting optical system that is effective to make the luminous intensity distribution upon a light entrance surface of light transmitting element (optical fiber bundle) into a distribution shape without a central void as in Claims 2 and 12. It is therefore believed that Claims 2 and 12 as amended by this amendment are completely distinguished from Tomioka et al. and are allowable.

Claims 22-24 have been rejected under 35 U.S.C. § 103(a) as unpatentable over Tomioka et al. With regard to the claims as amended by this amendment, this rejection is respectfully traversed.

Independent Claim 22 as amended is directed to an illumination optical system having a total reflection type transmitting element that illuminates a surface. In the illumination optical system, a light source illuminates a predetermined plane. The luminous intensity distribution upon the predetermined plane has a distribution shape with a central void. A converting optical system disposed between the predetermined plane and the light transmitting element directs light from the light source to the light transmitting element. The converting optical system is effective to make the luminous intensity distribution upon a light entrance surface of the light transmitting element into a distribution shape without a central void. The diameter of flux of light upon the predetermined plane is substantially equal to the diameter of flux of light upon the entrance surface of the light transmitting element.

According to Claim 22 as amended, a converting optical system which directs light from the light source formed by the imaging optical system to the optical fiber

bundle is effective to make the luminous intensity distribution upon a light entrance surface of light transmitting element (optical fiber bundle) into a distribution shape without a central void. As discussed with respect to Claims 2 and 12, Tomioka et al. discloses an arrangement in Fig. 16 in which the light beam is blocked by an arc 25 so that the distribution that is produced has a central void and a lens system of that images a light source image directly on the light entrance surface of the light guide without specifically changing the luminous intensity distribution. As a result, Tomioka et al. is directed away from the feature of a converting optical system that is effective to make the luminous intensity distribution upon a light entrance surface of light transmitting element into a distribution shape without a central void as in Claim 22. It is therefore believed that Claim 22 as amended is completely distinguished from Tomioka et al. and is allowable.

Newly added Claim 29 is directed to an illumination system that illuminates a surface using an optical fiber bundle. In the illumination system, a light source illuminates a predetermined plane. The luminous intensity distribution upon the predetermined plane has a distribution shaped with a central void. A converting optical system disposed between the predetermined plane and the optical fiber bundle directs light from the light source to the optical fiber bundle. The converting optical system is effective to make the luminous intensity distribution upon the light entrance surface of the optical fiber bundle into a distribution without a central void. The diameter of flux of light upon the predetermined plane is substantially equal to the diameter of flux of light upon the light entrance surface of the optical fiber bundle.

It is a feature of newly added Claim 29 that a converting optical system that is disposed between the predetermined plane and the optical fiber bundle and directs light from the light source to the optical fiber bundle is effective to make the luminous intensity distribution upon the light entrance surface of the optical fiber bundle into a distribution without a central void. As discussed with respect to Claims 2, 12 and 22, Tomioka et al.'s light blocking arrangement combined with a lens system that images a light source image directly on the light entrance surface of the light guide without specifically changing the luminous intensity distribution fails in any manner to teach or suggest the features of Claim 29. It is therefore believed that newly added Claim 29 is completely distinguished from Tomioka et al. and is allowable.

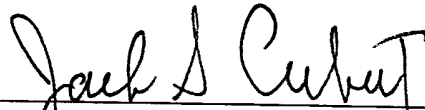
A review of the other art of record has failed to reveal anything which, in Applicant's opinion, would remedy the deficiencies of the art discussed above, as references against the independent claims herein. Those claims are therefore believed patentable over the art of record.

The other claims in this application are each dependent from one or another of the independent claims discussed above and are therefore believed patentable for the same reasons. Since each dependent claim is also deemed to define an additional aspect of the invention, however, the individual consideration or reconsideration, as the case may be, of the patentability of each on its own merits is respectfully requested.

In view of the foregoing amendments and remarks, Applicant respectfully requests favorable consideration and reconsideration and early passage to issue of the present application.

Applicant's attorney, Steven E. Warner, may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below listed address.

Respectfully submitted,

A handwritten signature in black ink, reading "Jack S. Cubert". The signature is written in a cursive style with a horizontal line underneath the name.

Attorney for Applicant

Jack S. Cubert

Registration No. 24,245

FITZPATRICK, CELLA, HARPER & SCINTO
30 Rockefeller Plaza
New York, New York 10112-3801
Facsimile: (212) 218-2200

JSC/lmj